11. SUMMARY OF CONFERENCE

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This conference has presented a one and one-half day sample of aerospace technology of interest to the electric power industry. Only a limited amount of the technology of interest was covered. Because of time restrictions, many subjects were omitted or abbreviated, for example, discussions of fabrication techniques, solid-state devices and circuits, high-temperature electrical materials, heat pipes, solid lubricants, emissivity coatings, fluidic controls, gas bearings, single-phase heat transfer, combustion, etc. The relevance of a considerable body of aerospace technology to the electric power industry has been clearly displayed. Opinions might vary as to the relative importance of the various parts of the conference; some of the highlights, as seen by the writer, are presented here.

The substantially lower fuel cost associated with breeder reactors is interesting because it will modify the balance of emphasis between efficiency, first cost, and reliability to which the power industry is currently accustomed; low fuel costs will reduce the importance of efficiency relative to the other factors of overall cost. The step from current burner reactors to future breeders is a large one and considerable technology work will have to be done before the breeder reactor is ready for service. A word of caution about liquid-metal systems is necessary. Liquid metals are unforgiving fluids. Failure to follow acceptable procedures rigorously almost always leads to trouble.

The smaller boilers discussed in connection with the Rankine system are feasible for use with pressurized water or liquid-metal-cooled reactors. Smaller boilers would not only decrease first cost but would reduce boiler failures by reducing the number of tubes that can fail which permits better quality control to be exercised.

The advance in the last two decades in dynamic analysis has been very substantial. The ability to predict and eliminate boiler instabilities and to analyze the dynamic behavior during the startup of complex systems is impressive evidence of that advance.

The gas turbine should have a larger place in power generation than it now occupies. The gas-fired open-cycle gas turbine described can achieve efficiencies in excess of 40 percent and represents a very attractive plant for regions where natural gas is readily available. Plants smaller than the 1000-megawatt plant discussed might be an attractive export item to countries with large available supplies of inexpensive gas or oil. The attractiveness of the high-temperature gas turbine suggests that efforts to use coal in gas turbines should receive greater emphasis. Perhaps the suggestion for using coal in a combined gas-turbine - steam-turbine system is interesting; perhaps a method for direct use of coal in gas turbines can be found.

The coupling of a closed-cycle gas turbine with a gas-cooled breeder reactor has an attractive simplicity when compared with three-loop systems, two of which are liquid-metal loops. Efficiencies in the high thirties, though lower than that of steam plants, may be acceptable because of the lower cost of breeder fuel. However, the implications of the higher reactor-temperature requirements and the cost of the heat exchangers, particularly the recuperator, need to be examined more thoroughly.

Because of economics, the methods used by NASA in achieving reliability are not all applicable to the electric power industry. However, some of the techniques should be considered. The searching review of all equipment designs in detail at the various stages of design with an eye toward reliability is extremely useful. One competent engineer charged with no other responsibility than reliability can do a great deal of good. A word of warning, however, is necessary. A routine, unimaginative reliability and quality assurance program increases costs with no real gains in reliability. The type of person selected for this function is the most important determinant of the result. Testing in the actual environment in which the hardware will perform is extremely important.

Automated checkout, startup, and operation is the current trend in many industries. NASA has recently started in this direction. More is being done and these experiences will probably be useful to industry. As an example (not described), a liquid-metal loop pumping sodium-potassium eutectic, or NaK, at 1100° F was operated completely unattended for a total loop operating time of about 14 000 hours, or more than 18 months. The test operator is called "the engineer with the four green eyes". The loop is automated, but since there are almost always people on site, a man takes a look in the control room once every few hours. If he sees that four adjacent green lights are all lit, then no major malfunction has occurred. Unattended operation will be extended to more complicated loops.

In all NASA work, advanced technology in instruments, materials, bearings and seals, and other such areas is often critical for the success of a new engine or system. Of the new technologies discussed, the extension of the use of infrared for temperature surveys is particularly interesting. This very powerful tool can be used in many ways in the electric power industry. The optical torquemeter is an interesting device. The use of rotary transformers to eliminate slip rings and thus permit the reliable instrumentation of turbogenerator rotors is an intriquing prospect.

In the mechanics of materials area, some of the failures encountered in engines have been caused by thermal fatigue. The average engineer is usually unaware of the thermal fatigue problem or how to analyze it. Even experienced developmental stress analysts, most of whose work deals with elastic rather than plastic phenomena, are often unfamiliar with the modern methods of analyzing thermal fatigue. The strength and cost of fiber-glass composites make them very attractive materials particularly for outdoor or underground service where their corrosion resistance offers added attraction.

The work in aerospace technology to increase the life of rolling-element bearings and low-leakage seals is extremely interesting. Today, these bearings and seals are used in situations which a decade ago would have been untenable. Service life is being greatly extended; however, the sizes and lifetimes are still short of that required for utility service. Considerable test experience in this direction is required before their use would be recommended. However, they are attractive and work is continuing.

In the more advanced areas of cryogenic electrical components and direct conversion, ultimate utility becomes harder to predict. In the case of cryogenic electrical components, considerable cryogenic technology is available and has been reduced to practice. A cryogenic transmission line, for example, can be built. When it is properly designed, it will work, and it will last. Although economics for utility use has not been analyzed, it should be considered carefully when a specific application indicates its possible desirability.

Direct conversion is a tantalizing area. A level of technology has not yet been achieved where it will soon make a major impact, but it is often "one discovery away." There are several rechargeable batteries which might make an excellent electric car if one or two of their problems can be solved. A low-cost, long-lived fuel cell making generation of electric power by this means economically attractive is perhaps one discovery short of feasibility. Thermoelectrics can be used today for special applications requiring a very small amount of power which is very reliable and simple. Thermionics and magnetohydrodynamics (MHD) operate at very high temperatures, and their practical utilization depends on the ability to build long-lived high-temperature devices at acceptable cost. This technology is not available today, but work is proceeding with those goals in mind. The fossil-fuel fired MHD appears to be of nearer term interest than any of the other MHD and thermionic systems.